

# CRS Report for Congress

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## North Korea's Nuclear Weapons: How Soon an Arsenal?

Sharon A. Squassoni  
Specialist in National Defense  
Foreign Affairs, Defense and Trade Division

### Summary

In December 2002, North Korea ended the eight-year freeze on its nuclear program by expelling international inspectors and restarting plutonium production facilities. In 2005, North Korea announced it had nuclear weapons and that it would withdraw from the Six Party talks, shut down its small reactor, and made preparations that some observers believe may be for a nuclear test. Before 2002, the CIA estimated that North Korea might have enough plutonium (Pu) for 1 or 2 weapons. Now, many assume that North Korea has successfully reprocessed the 8000 spent fuel rods at Yongbyon, which had previously been under seal, yielding enough Pu for 6 or 8 weapons. The Yongbyon reactor is estimated to produce plutonium for one weapon per year. Two unknown factors are the status of North Korea's uranium enrichment efforts and whether Pakistani scientist A.Q. Khan gave North Korea a weapons design, as he did to Libya. This report will be updated as needed.

### Background

In the early 1980s, U.S. satellites tracked a growing indigenous nuclear program in North Korea. A small nuclear reactor at Yongbyon (5MWe), capable of producing about 6kg of plutonium per year, began operating in 1986.<sup>1</sup> Later that year, U.S. satellites detected high explosives testing and a new plant to separate plutonium (a necessary step before turning the plutonium into metal for a warhead). In addition, the construction of two larger reactors (50MWe at Yongbyon and 200MWe at Taechon) added to the mounting evidence of a serious clandestine effort. Although North Korea had joined the Nuclear Nonproliferation Treaty in 1985, safeguards inspections began only in 1992. Those inspections raised questions about how much plutonium North Korea had produced covertly that still have not been resolved. In 1994, North Korea pledged, under the Agreed Framework with the United States, to freeze its plutonium programs and

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<sup>1</sup> 5MWe is a power rating for the reactor, indicating that it produces 5 million watts of electricity per day (very small). Reactors are also described in terms of million watts of heat (MW thermal).

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eventually dismantle them in return for several kinds of assistance.<sup>2</sup> At that time, Western intelligence agencies estimated that North Korea had separated enough plutonium for one to two bombs; other sources claimed it was enough for 4-5 bombs.

## Weapons Production Milestones

Acquiring fissile material — plutonium-239 or highly enriched uranium (HEU) — is the key hurdle in nuclear weapons development.<sup>3</sup> Producing these two materials is technically challenging; in comparison, many experts believe weaponization to be relatively easy.<sup>4</sup> North Korea has industrial-scale uranium mining, and plants for milling, refining, and converting uranium; it also has a fuel fabrication plant, a nuclear reactor, and a reprocessing plant — in short, everything needed to produce Pu-239. In its nuclear reactor, North Korea uses magnox fuel — natural uranium (>99% U-238) metal, wrapped in magnesium-alloy cladding. About 8000 fuel rods constitute a fuel core for the reactor.

When irradiated in a reactor, natural uranium fuel absorbs a neutron and then decays into plutonium (Pu-239). Fuel that remains in the reactor for a long time begins to become contaminated by the isotope Pu-240, which can “poison” the functioning of a nuclear weapon.<sup>5</sup> Spent or irradiated fuel, which poses radiological hazards, must cool after removal from the reactor. The cooling phase, estimated by some at five months, is proportional to the fuel burn-up.

Reprocessing — or separating the plutonium from waste products and uranium — is the next step. North Korea uses a PUREX separation process, like the United States. After shearing off the fuel cladding, the fuel is dissolved in nitric acid. Components (plutonium, uranium, waste) of the fuel are separated into different streams using organic solvents. In small quantities, separation can be done in hot cells, but larger quantities require significant shielding to prevent deadly exposure to radiation.<sup>6</sup>

Most experts agree that North Korea has mastered the engineering requirements of plutonium production. Its 5MWe nuclear reactor operated from 1986 to 1994, restarting in January 2003. North Korean officials claimed to have separated plutonium in hot cells and tested the reprocessing plant in 1990, and to have reprocessed all 8000 fuel rods from the 5 MWe reactor between January and June 2003. Some analysts have reported that the 5MWe reactor operated at low efficiencies. The January 2004 unofficial U.S. delegation reported that “All indications from the display in the control room are that the reactor is operating smoothly now... However, we have no way of assessing independently

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<sup>2</sup> See CRS Issue Brief IB91141, *North Korea's Nuclear Weapons Program*.

<sup>3</sup> Highly enriched uranium (HEU) has 20% or more U-235 isotope; weapons-grade uranium is 90% or more U-235.

<sup>4</sup> While the physical principles of weaponization are well-known, producing a weapon with high reliability, effectiveness and efficiency without testing holds significant challenges.

<sup>5</sup> Plutonium that stays in a reactor for a long time (reactor-grade, with high “burn-up”) contains about 20% Pu-240; weapons-grade plutonium contains less than 7% Pu-240.

<sup>6</sup> Hot cells are heavily shielded rooms with remote handling equipment for working with irradiated materials.

how well the reactor has operated during the past year.”<sup>7</sup> The same delegation reported that the reprocessing “facility appeared in good repair,” in contrast to a 1992 IAEA assessment of the reprocessing plant as “extremely primitive.” In the end, however, North Korea’s potential for developing a large nuclear arsenal depends on the completion of the two larger reactors and progress in the reported uranium enrichment program.

There is virtually no information on North Korean nuclear weapons design. The simplest, gun-type design requires no testing, but can only be made with HEU, not plutonium. Implosion devices, which use sophisticated lenses of high explosives to compress plutonium, are more likely to require testing. Some observers believe that North Korean testing of high explosives with particular compression patterns in the 1980s indicates the ability to manufacture an implosion device.<sup>8</sup> In April 2005, media reported that North Korea was readying a nuclear test site near Kilju, but the evidence did not seem conclusive.<sup>9</sup> A nuclear test by North Korea could provide more information on whether it has a workable nuclear weapon and what kind of design it is — simple or more complex (i.e., a boosted fission or composite pit design). It is unknown whether Pakistani scientist A.Q. Khan provided North Korea with the same Chinese-origin nuclear weapon design he provided to Libya.<sup>10</sup> If so, North Korea might develop a reliable warhead for ballistic missiles without testing. Such a warhead needs to be small, light and robust enough to tolerate the extreme conditions encountered through a ballistic trajectory. DIA Director Admiral Jacoby, in a hearing before the Senate Armed Services Committee on April 28, 2005, stated that North Korea had the capability to arm a missile with a nuclear device.

In January 2004, North Korean officials showed an unofficial U.S. delegation what they claimed was “scrap” from a plutonium (Pu) casting operation; the officials stated that the metal was alloyed. Alloying plutonium with other materials, according to Dr. Siegfried Hecker of Los Alamos National Laboratory, is “common in plutonium metallurgy to retain the delta-phase of plutonium, which makes it easier to cast and shape” (two steps in weapons production).<sup>11</sup> Hecker, a delegation member, assessed that the stated density of the material was consistent with plutonium alloyed with gallium or aluminum. If so, this could indicate a certain sophistication in North Korea’s handling of Pu metal, but Hecker could not confirm that the metal was indeed plutonium, that it was alloyed, or that it was from the most recent reprocessing campaign, without conducting actual tests of the material.

## Estimating Nuclear Material Production

Most estimates of nuclear weapon stockpiles are based on estimated fissile material production. Factors in plutonium production include the average power level of the

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<sup>7</sup> Siegfried Hecker, Jan. 21, 2004, testimony before Senate Foreign Relations Committee.

<sup>8</sup> Don Oberdorfer, *The Two Koreas*, (MA: Addison-Wesley, 1997), p. 250.

<sup>9</sup> First reported by the *Wall Street Journal* in the Seoul, on-line edition, Apr. 22, 2005. See also “What Are Koreans Up To? U.S. Agencies Can’t Agree,” *New York Times*, May 12, 2005.

<sup>10</sup> See also CRS Report RL32745, *Pakistan’s Nuclear Proliferation Activities and the Recommendations of the 9/11 Commission: U.S. Policy Constraints and Options*.

<sup>11</sup> Hecker, January 21, 2004 testimony before SFRC.

reactor; days of operation; how much of the fuel is reprocessed and how quickly, and how much plutonium is lost in production processes. According to North Korea, the 5MWe reactor performed poorly early on, unevenly irradiating the rods. There is no data on the reactor's current performance or the reprocessing facility's efficiency. North Korea told the IAEA that during the 1990 "hot test," it lost almost 30% of the plutonium in the waste streams.<sup>12</sup> A key consideration is whether or not the reprocessing plant can successfully run continuously, since frequent shutdowns can lead to plutonium losses. According to North Korean officials in January 2004, the plant throughput is 110 tons of spent fuel annually, about twice the amount of fuel in the 5MWe reactor. A final factor in assessing how many weapons North Korea can produce is North Korea's technical sophistication. The international standard is 8kg of Pu per weapon (and 25kg for HEU), but technical experts agree that it is possible to make nuclear weapons with less than half that amount. North Korea's abilities in this area are unknown.

## What Does North Korea Have Now?

Secretary of State Powell stated in December 2002 that "We now believe they [North Koreans] have a couple of nuclear weapons and have had them for years."<sup>13</sup> On February 10, 2005, North Korea announced that it had manufactured "nukes" for self-defense and that it would bolster its nuclear weapons arsenal.<sup>14</sup>

**Has North Korea reprocessed the existing spent fuel?** On July 13, 2003, North Korean officials told U.S. officials in New York that they had completed reprocessing the 8000 fuel rods on June 30.<sup>15</sup> On January 8, 2004, North Korean officials told the unofficial U.S. delegation that the reprocessing campaign began in mid-January 2003 and ended at the end of June 2003. In all, they reportedly reprocessed 50 tons of spent fuel in less than six months, which tracks with earlier estimates that North Korea could reprocess about 11 tons/month, roughly enough plutonium for 1 bomb per month.

The unofficial U.S. delegation visiting in January 2004 concluded that the spent fuel pond no longer held the 8000 fuel rods and surmised that those fuel rods could have been moved to a different storage location, but not without significant health and safety risks. The delegation was not allowed to visit the Dry Storage Building, where the fuel rods likely would have been stored before reprocessing. If the 8000 fuel rods from the 5 MWe reactor have been reprocessed, they would yield, according to one estimate, between 25 and 30kg of plutonium, enough for 5 or 6 weapons.

The exact amount of plutonium that might have been reprocessed is not known. The January 2004 U.S. visitors to the plant were not allowed to visit waste facilities, and North Korean officials did not reveal any operating difficulties with the plant, stating that the reprocessing campaign was conducted continuously (four 6-hr shifts). U.S. efforts to

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<sup>12</sup> David Albright and Kevin O'Neill, editors, *Solving the North Korean Nuclear Puzzle*, ISIS Report, ISIS Press, 2000, p. 88.

<sup>13</sup> Transcript of Dec. 29, 2002 *Meet the Press*.

<sup>14</sup> "North Korea Says It Has Nuclear Weapons and Rejects Talks," *New York Times*, Feb. 10, 2005.

<sup>15</sup> "North Korea Says It Has Made Fuel For Atom Bombs," *New York Times*, July 15, 2003.

detect Krypton-85 (a by-product of reprocessing) reportedly suggested that some reprocessing had taken place, but were largely inconclusive.

## **Adding to the Arsenal**

**Make New Plutonium in 5 MWe reactor.** On February 6, 2003, North Korean officials announced that the 5 MWe reactor was operating, and commercial satellite photography confirmed activity in March. In January 2004, North Korean officials told the unofficial U.S. delegation that the reactor was now operating smoothly at 100% of its rated power. The U.S. visitors noted that the display in the reactor control room and steam plumes from the cooling towers confirmed operation, but that there was no way of knowing how it had operated over the last year. In April 2005, the reactor was shut down, and on May 11, 2005, North Korean officials stated they harvested fuel rods for weapons.<sup>16</sup>

A common estimate is that the reactor generates 6kg of Pu per year, roughly 1 bomb per year, but the reactor would likely be operated for several years before fuel is withdrawn. Assuming a six-month cooling period for plutonium, North Korea would be ready to reprocess about 12 kg of Pu by October 2005 and convert into metal by April 2006, adding potentially another two nuclear weapons to the stockpile.

**Bring New Reactors On-Line.** The reactors at Yongbyon (50MWe) and Taechon (200MWe) are likely several years from completion. U.S. visitors in January 2004 saw heavy corrosion and cracks in concrete building structures at Yongbyon, reporting that the reactor building “looks in a terrible state of repair,” but they did not visit the Taechon site.<sup>17</sup> The CIA estimates that the two reactors could generate about 275kg of plutonium per year.<sup>18</sup> In January 2004, North Korean officials told the unofficial U.S. delegation that they are evaluating what to do with both reactors.

**Produce Highly Enriched Uranium for Weapons.** A 2002 unclassified CIA working paper on North Korea’s nuclear weapons and uranium enrichment estimated that North Korea “is constructing a plant that could produce enough weapons-grade uranium for two or more nuclear weapons per year when fully operational — which could be as soon as mid-decade.”<sup>19</sup> Such a plant would need to produce more than 50kg of HEU per year, requiring cascades of thousands of centrifuges. The paper noted that in 2001, North Korea “began seeking centrifuge-related materials in large quantities.” Although not much is known about the program or facilities, Pakistan’s A.Q. Khan probably offered the same relatively sophisticated P-2-design centrifuges to North Korea as he did to Libya and Iran.

For North Korea, a centrifuge enrichment program offers three advantages: such plants are difficult to locate and target, making them less vulnerable to military strikes

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<sup>16</sup> “North Koreans Claim to Extract Fuel for Nuclear Weapons,” *New York Times*, May 12, 2005.

<sup>17</sup> Hecker Jan. 21, 2004 testimony before SRFC.

<sup>18</sup> CIA unclassified point paper distributed to Congressional staff on Nov. 19, 2002.

<sup>19</sup> Ibid.

than reactors or reprocessing plants. HEU also could give the North Koreans the option of producing either simpler weapons (gun-assembly type) or more sophisticated weapons (using composite pits or boosted fission techniques). Third, an HEU program is a bargaining chip to use with the United States. However, a centrifuge enrichment plant requires considerable industrial sophistication.

## How to Verify North Korean Claims?

Information about North Korea's nuclear weapons production has depended largely on remote monitoring and defector information, with mixed results. Satellite images correctly indicated the start-up of the 5 MWe reactor, but gave no detailed information about its operations. Satellites detected truck movements at Yongbyon in late January 2003, but could not confirm that the trucks were moving spent fuel to the reprocessing plant;<sup>20</sup> satellite imagery reportedly detected some activity at the reprocessing plant in April 2003, but U.S. officials could not confirm that large-scale reprocessing was taking place;<sup>21</sup> and, satellite imagery could not peer into an empty spent fuel pond, which was shown to U.S. visitors in January 2004.

U.S. visitors to Pyongyang in January 2004 could not confirm North Korean claims of having reprocessed the spent fuel or that the material shown was in fact plutonium. With greater access to the material and North Korean cooperation, it would be possible to verify those claims by using a variety of scientific techniques and measurements.

In February 2005, NSC officials reportedly tried to convince Asian allies of North Korea's Pu reprocessing and production of uranium hexafluoride (UF<sub>6</sub>, an input to enrichment plants) by sharing information that plutonium had been found on the outside of Libyan shipping containers. However, allies and experts questioned how the plutonium was characterized as North Korean (some say by a process of elimination) and suggested that North Korea might have been transshipping Pakistani UF<sub>6</sub> to Libya.<sup>22</sup> In any event, North Korean production of UF<sub>6</sub> does not confer a capability to enrich the UF<sub>6</sub>, as some may have concluded.

Media reported in April 2005 that nuclear test preparations, including a reviewing stand and the movement of large amounts of steel and concrete, might be underway at a site near Kilju. In contrast to conventional tunneling, preparing underground nuclear test sites usually includes digging, placing the device and associated monitoring equipment in the hole, and then stemming (filling) the hole with gravel and concrete.<sup>23</sup> A nuclear test, of course, would confirm North Korea's nuclear capabilities.

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<sup>20</sup> "Reactor Restarted, North Korea Says," *Washington Post*, Feb. 6, 2003.

<sup>21</sup> "US Suspects North Korea Moved Ahead on Weapons," *New York Times*, May 6, 2003.

<sup>22</sup> "North Korea May Have Sent Libya Nuclear Material, U.S. Tells Allies," *Washington Post*, Feb. 2, 2005 and "China Doubts U.S. Data on North Korean Nuclear Work," *New York Times*, Mar. 7, 2005.

<sup>23</sup> "U.S. Cites Signs of Korean Steps to Nuclear Test," *New York Times*, May 6, 2005.